Final Report
Participatory Rural Energy Services in
Karnataka (PRESK)

Technical Review of Report on *Efficiency Improvement of G. Hoshhalli Feeder at Gubbi, Karnataka*

January 2004

Prepared by

⌁ Nexant

Contract No. 386-C-00-03-00135-00

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USAID SARI/Energy Program
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Acknowledgments

List of Acronyms

A	Ampere
BESCOM	Bangalore Electricity Supply Company
BJ/KJ	Bhagyajyothi/Kutirjyothi connections
bU	billion units
3 EC	Energy Economy and Environmental Consultants
HT	High Tension
IP	Irrigation Pump Set
Km	Kilometer
kV	kilo Volt
kVA	kilo Volt Ampere
kW	kilo Watt
LT	Low Tension
MU	million units
MUSS	Multi Unit Sub Station

Contents

This is the technical review of the report on 'Efficiency Improvement of G.Hosahalli Feeder at Gubbi, Karnataka' prepared by Energy Economy and Environmental Consultants (3 EC, Bangalore) for BESCOM.

The objective of the proposal is to demonstrate a pilot "Efficiency Improvement in Rural Distribution" for the feeders in Gubbi 110/11 kV MUSS.

The study is initially confined to one feeder, namely, G. Hoshalli which is one of the 12 feeders supplied from the substation. The feeder caters to 15 villages with 709 pump sets, 1166 lighting connections, 6 commercial services and 140 BJ/KJ* connections.

The average annual consumption recorded by the feeder is 7.6 MU for the years 2001 and 2002. The feeder provides 3 phase supply for 2400 hours, 3500 hours in 1-phase connection and there is no supply for 2860 hours.

For a delivered load of 4682 kW, (300 A) power loss is 1538 kW which amounts to nearly **33%**.

The proposed modification involves

(i) Bifurcation of the initial section (3.3 km) of the 11 kV feeder carrying the total current into two separate feeders supplying two groups. This reduces losses and improves voltage profile.

(ii) Rather than make the total system L T -less, it is proposed to make clusters of IP sets fed from 10, 16 or 25 kV A 11000/430 Volt transformers.

(iii) The transformers are fitted with meter cum switching devices. The meters can be read from a distance without opening the boxes in which they are housed.

(iv) The switches can be controlled by remote signals. The main feeder remains energized for 24 hours, but clusters of IP sets are provided power supply for 6-8 hours a day or according to the policies of the supply company.

Special single phase transformers are provided for supplying lighting and commercial load for 24 hours.

The following steps have been already undertaken by 3EC and detailed in the reports presented.

Based on the above analysis, the energy savings claimed are as below.

Energy savings with network up gradation and Avoidance of single phasing (Table 12 of the report).

Loss reduction m 3 phase condition	0.18	MU/yr
Demand cutoff by avoiding single phasing	3.98	MU/yr
Subtotal	4.17	MU/yr
Additional losses due to line energized for 24 hrs	0.45	*MU/yr*
Nett savings	3.72	MU/yr

Conclusions drawn by the project proposers (3EC) are:

"The anticipated savings from adopting remote load management avoiding single phasing is substantial. Hence the investment for the installation of the metering system which enables load management is justified."

The implementation plan is provided (Fig. 3).

The urgency of undertaking a project such as this can hardly be overstated. In fact rationalization of Distribution of electrical power in India is long overdue. Systems losses in power distributions vary from one state to another. Since these losses vary approximately as P^2, where P is the connected load, the losses vary steeply from month to month and year to year.

In Karnataka state, out of nearly 3700, 11 kV feeders about 1200 are long and overloaded and need immediate attention. The terminal voltages are very low indeed. As a result, pump motors either burn out or they draw high currents, which cause further copper loss (I^2R).

Rationalizing the 11 kV network is a major initial step. But the LT losses are also high and it is at the LT level where thefts or unauthorized pump set connections are common.

In view of the power/energy scarcity, continuous power cannot be supplied for the IP sets which in Karnataka state consume about **25%** of the electrical energy of the state. To make things worse, most of the 1.3 million IP sets are not metered and the energy consumed by these are hardly paid for. This not only leads to huge revenue losses but makes energy accounting almost impossible.

The electrical energy produced/purchased in Karnataka state during 2001-2002 was 29.2 billion units. Out of this only 10.2 bU was metered and billed. Attempts to meter and read IP set consumptions meet with hostility. Electrical energy consumption for lighting and commercial energy used in rural areas constitute a small fraction (**<5%**) of the total electrical energy consumed. This energy is usually metered and billed (except BJ/KJ consumption). Single phase power is supplied to this sector at night in order to yet prevent the IF set operation and causing overloads. 3 phase power is supplied for 6-8 hours, and single phase for about 10-8 hours with no supply for the rest of the day (see Fig. 1 supplied by 3&). The single phase power supply is however being grossly abused by the IF set users who use converters to enable IP set motors to run off the so called single phase supply. So the rural power supply has three major problems:

1) A large number of rural feeders have simply grown in an unplanned manner and hence the losses are very high and voltage regulation is very poor.
2) The energy supplied is nearly not metered beyond the 11 kV substations.
3) 3 Phase power is supplied for IP sets for 6-8 hours. Single-phase power supplied for lighting and commercial loads is grossly abused by IP set owners to run IP sets using converters.

- The proposed project seems to address almost all the problems.

1) Rationalizing the 11 k V feeders and reducing LT lines reduce losses and improve voltages (The improvement of voltage profile has not been shown in the report).

2) Remote control of power supply to clusters of IP sets and supplying lighting and commercial loads through single phase transformers (which cannot be easily converted to run 3 phase motors) remove the problems associated with the present practice of abusing the "single phase supply" presently provided by short-circuiting two phases at the source. Staggered operation of clusters of pump set will reduce losses significantly*.

3) Installation of a large number of remotely read concealed meters close to the cluster of a few IP sets will significantly alleviate the energy accounting problem.

The basic idea of the project proposal is technically sound and worth supporting provided

(ii) It is assured that Secure Meters Ltd. can supply switches that can interrupt large currents, activated by remote signals and repeated operations are possible. (in case remote switching is not feasible i.e. Secure Meters Ltd. or any other agency are not able to supply the specified switches, the project proposal has to be completely recast, but not to be abandoned).

(iii) The financial returns depend critically on the estimate of energy savings. The computation of energy savings made in the proposal is simplistic and inaccurate (data in Table 12 [cited] and Fig. 1 seem to be incompatible). **This needs to be revised according guidelines provided through extensive discussions.**

(iv) The total cost needs to be reduced particularly in view of the fact that we are dealing with a "pilot project" and the returns should be visible as early as possible so thatsimilar, and when feasible, more modified projects are replicated for large scale improvement of the distribution system. In other words, it is advisable to settle for a more pragmatic suboptimal solution rather than aim at the optimum. Cost saving may be effected after detailed discussions with BESCOM. Initial cost may be reduced by

(a) avoiding replacement of **25%** of the IP sets with more efficient pump sets

(b) avoiding the use of 0.9 km cable connection in branching out the initial section of the 11 kV feeder and finding cheaper alternatives if possible.

(c) Settling for transformers with aluminum conductors rather than with copper conductors if the price differential is high

(d) Making the IP set clusters a little larger than what has been proposed. This will reduce

   (i) the number of transformers

   (ii) the number of meters

   (iii) the number of switches. In other words opt mainly for 25 kVA and 16 kVA transformers and reduce the use of 10 kVA transformers. The argument against this suggestion could be that we should move increasingly to an L T -less system to avoid "hooking" and minimize losses and hence we should avoid larger clusters with longer L T lines. A cost calculation will provide the necessary guideline.

   (iv) Critical study to ascertain whether large 11 kV capacitors may be required or not. It may be possible to avoid them without significantly affecting saving on losses or voltage regulation.

* If all the IP sets are not provided 3 phase supply simultaneously, distribution losses may be substantially reduced. For example, if all lP sets are arranged into three clusters and each cluster is supplied 3-phase power for 8 hours a day sequentially the distribution losses in order to supply the IP sets would almost be 1/3rd of the losses when all lP sets are supplied together $3 \times (p/3)^2 K = 1/3\ p^2 K$

(v) It needs to be pointed out at this stage that the proposed "black box" containing a meter and the switch may be tampered with by the IP set users, although it is proposed to mount them on poles. By suitably short circuiting these boxes, the IP set users can avail themselves of 24 hours 3 phase power supply. This will make the existing problems worse than what they are now.

It is suggested that the meter/switch suppliers (Secure Meters Ltd.) be made aware of this problem. It may not be difficult to make the meter/switch an integral part of the transformer so that it may not be possible to bypass the meter/switch without discontinuing the 3 phase supply. The meter suppliers need to consult the transformer manufacturers to evolve such a design.

(vi) Revise the proposal keeping in view the suggestions made, recomputing losses and savings and reviewing the implementation chart if necessary.

The improvement in voltage regulation has not been presented or displayed in the project report and needs to be emphasized.

(vii) If the meter/switches are available and the project is accepted for implementation, a suitable software should be developed to control switching of the clusters keeping in view balanced operation and leading to minimum losses.

- The software should enable appropriate consolidation of data generated by the meters and their suitable documentation and display.

- Decentralized generation of power for feeding the tail end loads, which will not only reduce demand on central power generation but reduce losses and improve terminal voltages very significantly, may be tried as one of the strategies - not necessarily in this project but in any future ones that 3 EC-BESCOM may undertake.

The proposal may be accepted for implementation in a revised form incorporating suggestions as outlined in section 4.0 and others that may be made by BESCOM. The loss estimates need to be computed correctly.

If properly revised, executed and monitored this project proposal has the potential of serving as a model for improving rural distribution networks, especially in power/energy starved, states with large agricultural loads, and making energy accounting possible through measurements.

1. Improvement of voltage profile following systems improvement is of critical importance. Load flow studies routinely bring out the voltages at various nodes. The report has, possibly inadvertently, underplayed this: It is strongly suggested that the revised project report should highlight the changes in voltage profile following systems improvement.

2. It is the normal practice to express percentage loss as:

<div style="margin-left: 2em;">

$\underline{\text{Losses in kW}}$ x **100%**
Sending end power (kW)
[in terms of power]

</div>

or

<div style="margin-left: 2em;">

$\underline{\text{Losses in units over a period}}$ x **l00%**
sending end energy over the same period
[in terms of energy]

</div>

The authors of the report have defined percentage losses for 11 kv as

<div style="margin-left: 2em;">

$\underline{\text{Losses in k W}}$ x **100%**
Useful load in kW

</div>

whereas for LT they have defined percentage losses as

<div style="margin-left: 2em;">

$\underline{\text{Losses in kW}}$ x **100%**
Load delivered from DTC (kW)

</div>

The definition followed in the report for 11 k V network hugely inflates the percentage loss. e.g. Table 1, (report) HT losses presented as **20.4%** is, according to standard definition, **13.4%** computing these values for peak load and (300A) further exaggerates the losses.

3. It has been assumed in the report that power/energy consumed by IP sets remains constant before and after systems improvement irrespective of the improved voltage. This assumptions is somewhat simplistic but may be accepted in view of the wide variabilities that exist and the near impossibility of predicting the behavior of the IP sets which are almost entirely non-standard. By and large, however, improved voltage will provide larger yield of water, demanding lesser hours of operation. This should be investigated closely by the project proposer, preferably by a few experimental evidence. Reduced hours of IP Set use, following systems improvement, will enhance the value of the proposal.

4. The use of capacitors in a 11 kV system does not always have the kind of effect as obtained in HV transmission systems, especially on voltage. If the total initial cost needs to be kept as low as possible and maintenance trouble free, it is suggested that load flow studies are carried out with and without proposed capacitors before deciding on installing them. LT capacitors installed on the secondaries of the transformers may be cheaper and provide relatively trouble free operation.

5. Calculation of energy saving is rather simplistic as has been pointed out in the text of this review. Financial returns of this project have been based on projected energy savings which obviously need to be calculated more accurately. Take Table 14 (report), for example: Although it has not been stated explicitly, it is presumed that items in the first column in the table specify *monthly* average of 3-phase currents during 2001-02. The elements in the reduction in load in the modified system corresponding to each month on the assumption of the feeder catering to same useful load under both the conditions (i.e. present system and after implementation). The kW saving, for each month has been multiplied by 200 hours (3 phase supply for each month). The energy used for single phase operation of IP sets is 3.16 MU as against 2.3 MU for 3 phase power supply [Table 2]. It seems somewhat surprising that IP set consumption using converters, operated illegally, should exceed the consumption during normal 3 phase operation to such an extent. The fact that the so called single phase supply is provided for longer hours does not quite explain this obvious anomaly. It is, however, necessary that correct values are estimated from the procured data [Fig 1] since the energy used at present from single phase supply is being shown as savings when the system is modified.

Revised estimates are to be carried out as per discussions with 3EC. The energy supplied during a month may be obtained from the average load curves for that month for (a) 3 phase power supply (b) 1 phase power supply. Losses for (a) and (b) need to be computed properly. The losses for modified systems are also worked out. Total energy calculated for 12 months and the sum of the losses as in each month are added *for* existing and modified systems to *compute savings*.